

FEDERAL AVIATION AGENCY

Washington 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 514

SUBJECT: FUEL FLOWMETERS

TSO-C44a

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Technical Standard Orders for Aircraft Materials,  
Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Flight Standards Service, Federal Aviation Agency, Washington 25, D.C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:

- (a) Name and address of the manufacturer responsible for compliance,
- (b) Equipment name, or type or model designation,
- (c) Weight to the nearest pound and fraction thereof,
- (d) Serial number and/or date of manufacture, and
- (e) Applicable Technical Standard Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

## SUBPART B

§ 514.43 Fuel flowmeters - TSO-C44a--(a) Applicability - (1) Minimum performance standards. Minimum performance standards are hereby established for fuel flowmeters which specifically are required to be approved for use on civil aircraft of the United States. New models of fuel flowmeters manufactured for installation on civil aircraft on or after November 1, 1961, shall meet the standards set forth in SAE Aeronautical Standard AS-407B, "Fuel Flowmeters", revised March 1, 1960,<sup>1/</sup> with exceptions and additions to the standards listed in subparagraph (2) of this paragraph.

(2) Exceptions and additions. (i) Correction to Section 1. of AS-407B: As referenced in this TSO, AS-407B specifies minimum requirements for fuel flowmeters for use on reciprocating engine or turbine powered civil aircraft. In addition, the following specifically numbered subsections in AS-407B do not concern minimum performance and, therefore, are not essential to compliance with this section: subsections 3.1, 3.2 and 4.2.1.

(ii) Thermal shock: This test shall apply to any hermetically sealed components. The component shall be subjected to four cycles of exposure to water at  $85^{\circ} \pm 2^{\circ}$  C. and  $5^{\circ} \pm 2^{\circ}$  C. without evidence of moisture penetration or damage to coating or enclosure. Each cycle of the test shall consist of immersing the component in water at  $85^{\circ} \pm 2^{\circ}$  C. for a period of 30 minutes, and then within 5 seconds of removal from the bath, the component shall be immersed for a period of 30 minutes in the other bath maintained at  $5^{\circ} \pm 2^{\circ}$  C. This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed. Following this test, the component shall be subjected to the Sealing test specified in (iii). No leakage shall occur as a result of this test.

(iii) Sealing: This performance test shall apply to any hermetically sealed components. The component shall be immersed in a suitable liquid, such as water. The absolute pressure of the air above the liquid shall then be reduced to approximately 1 inch of mercury (Hg) and maintained for 1 minute, or until air bubbles cease to be given off by the liquid, whichever is longer. The absolute pressure shall then be increased by 2 1/2 inches Hg. Any bubbles coming from within the indicator case shall be considered as leakage and shall be cause for rejection. Bubbles which are the result of entrapped air in the various exterior parts of the case shall not be considered as leakage. Other test methods which provide evidence equal to the immersion test of the integrity of the instrument's seals may be used. If the component incorporates nonhermetically sealed appurtenances, such as a case extension, these appurtenances may be removed prior to the Sealing test.

(iv) Correction to subsection 3.3.1: Under column A, the temperature values for unheated areas (Temperature Uncontrolled) shall be  $-55^{\circ}$  to  $70^{\circ}$  C.

(b) Marking. In addition to the markings specified in Subpart A, range (transmitters only) and electrical rating shall be shown.

(c) Data requirements. (1) The manufacturer shall maintain a current file of complete design data.

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<sup>1/</sup> Copies may be obtained from the Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

(2) The manufacturer shall maintain a current file of complete data describing the inspection and test procedures applicable to his product, (See paragraph (d), Quality Control, of this section).

(3) Six copies each, except where noted, of the following shall be furnished to the Chief, Engineering and Manufacturing Division, Flight Standards Service, Federal Aviation Agency, Washington 25, D. C.:

(i) Manufacturer's operating instructions and instrument limitations.

(ii) Drawings of major components or photographs showing exploded views of instruments.

(iii) Installation procedures with applicable schematic drawings, wiring diagrams, and specifications. Indicate any limitations, restrictions, or other conditions pertinent to installation with the statement of conformance certifying that the instrument conforms to this section.

(iv) One copy of the manufacturer's test report.

(d) Quality control. Each fuel flowmeter shall be produced under a quality control system, established by the manufacturer, which will assure that each fuel flowmeter is in conformity with the requirements of this section and is in condition for safe operation. This system shall be described in the data required under paragraph (c)(2) of this section. A representative of the Administrator shall be permitted to make such inspections and tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this section.

(e) Previously approved equipment. Fuel flowmeters approved by the Administrator prior to November 1, 1961, may continue to be manufactured under the provisions of their original approval.

(f) Effective date. November 1, 1961.

FUEL FLOWMETERS

Issued 11-1-48  
Revised 3-1-60

1. PURPOSE: To specify minimum requirements for Fuel Flowmeters for use primarily in reciprocating engine powered civil transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. SCOPE: This Aeronautical Standard covers two basic types of instruments, or combinations thereof, intended for use in indicating fuel consumption of aircraft engines as follows:

TYPE I - Measure rate of flow of fuel used.

TYPE II - Totalize amount of fuel consumed or remaining.

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:

- a. Name of component (Fuel Flowmeters)
- b. SAE AS 407B
- c. Manufacturer's part number
- d. Manufacturer's serial number or date of manufacture
- e. Manufacturer's name and/or trademark
- f. Range (Transmitters only)
- g. Rating (Electrical - if required)

3.3 Environmental Conditions: The following conditions have been established as design requirements only. Tests shall be conducted as specified in Sections 5, 6 and 7.

3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function over the range of ambient temperature shown in Column A below and shall not be adversely affected by exposure to the range of temperature shown in Column B below:

<u>INSTRUMENT LOCATION</u>	<u>A</u>	<u>B</u>
Heated Areas (Temp. Controlled)	-30 to 50C	-65 to 70C
Unheated Areas (Temp. Uncontrolled)	-55 to 50C	-65 to 70C
Power Plant Compartment	-55 to 70C	-65 to 100C
Power Plant Accessory Compartment	-55 to 70C	-65 to 100C



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3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately 32C.

3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

<u>INSTRUMENT LOCATION IN AIR FRAME</u>	<u>CYCLES PER SEC.</u>	<u>MAX. DOUBLE AMPLITUDE (INCHES)</u>	<u>MAX. ACCELERATION</u>
Power Plant Mounted	5 - 150	0.100	20g
Wings & Empennage	5 - 500	0.036	10g
Fuselage	5 - 500	0.036	5g
Panel or Rack (Vibration Isolated)	5 - 50	0.020	1.5g

3.3.4 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 feet to 40,000 feet standard altitude, per NACA Report 1235, except as limited by the application of para. 3.3.1. The instrument shall not be adversely affected following exposure to an ambient pressure of 50 in. Hg. absolute.

3.4 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in electronic equipment installed in the same aircraft as the instrument.

3.5 Magnetic Effect: The magnetic effect of the indicator shall not adversely affect the operation of other instruments installed in the same aircraft.

#### 4. DETAIL REQUIREMENTS:

4.1 Indicating Method: One or a combination of the following methods of indication shall be employed.

4.1.1 Type I Instruments: Rotating pointer with fixed graduated dial or counter type indication. Clockwise pointer motion shall indicate increasing rate of flow.

4.1.2 Type II Instruments: A counter shall be employed to indicate either the fuel consumed or quantity remaining.

#### 4.2 Dial Markings:

4.2.1 Finish: Unless otherwise specified by the user, matte white material shall be applied to major graduations, numerals and pointers. Non-functional surfaces shall be a durable dull black.

4.2.2 Numerals: Sufficient numerals shall be marked to positively and quickly identify all graduations. Numerals shall distinctly indicate the graduations to which each applies.

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- 4.2.3 Graduations: Major graduations shall be used at intervals not to exceed 10% of full scale value.
- 4.2.4 Counters: When counters are incorporated in the instrument they shall indicate increments no larger than every 10 pounds or 2 gallons.
- 4.2.5 Visibility: The pointer and all dial markings or counters shall be visible from any point within the frustum of a cone whose side makes an angle of not less than 30 degrees with the perpendicular to the dial, and whose small diameter is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed 0.25 inch.
- 4.3 Flow Direction: The direction of flow through the transmitter shall be permanently and legibly marked thereon.
- 4.4 Fuel Characteristics: Unless otherwise specified, the fuel flowmeter shall be designed to meet the performance requirements included herein when used with 100 octane aviation gasoline with a specific gravity of  $0.715 \pm .003$  at a temperature of 15 to 25C.
- 4.5 Power Variations: Unless otherwise specified, the fuel flowmeter shall properly function with  $\pm 15\%$  variation in DC voltage and/or  $\pm 10\%$  variation in AC voltage and  $\pm 5\%$  in frequency.
- 4.6 Safety Provisions: Each transmitter shall provide adequate flow incase of malfunctioning in flight either by means of an automatic by-pass or a non-flow restricting mechanism.
5. TEST CONDITIONS:
- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury, and at an ambient temperature of approximately 25C and a relative humidity not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowances shall be made for the variations from the specified conditions.
- 5.2 Vibration: (to minimize friction) Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Section 3.3.3 with the following characteristics:
- 5.3.1 Linear Motion - Vibration: Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument.

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- 5.3.2 Circular Motion - Vibration: Vibration equipment shall be such that a point on the instrument case will describe a circle, in a plane inclined  $45^{\circ}$  to the horizontal plane, the diameter of which is equal to the double amplitude specified.
- 5.4 Power Conditions: Unless otherwise specified, all tests shall be conducted at the power rating recommended by the manufacturer.
- 5.5 Position: Unless otherwise specified, all tests shall be conducted with the instrument mounted in its normal operating position.
6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments or components of such shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aeronautical Standard including the following requirements where applicable.
- 6.1 Scale Errors: The instrument scale error shall be determined at all major graduations. This test shall be conducted by subjecting the instrument first with rates of flow increasing, then with rates of flow decreasing. With the rate of flow increasing, the rate shall be brought up to, but shall not exceed, the rate specified to give the desired reading, and with the rate of flow decreasing, the rate shall be brought down to, but shall not fall below, the rate specified to obtain the desired reading. The error at each major graduation shall not exceed 3% of full scale reading. The difference between the reading on increasing rate of flow and the reading on decreasing rate of flow at each major graduation shall not exceed 1% of full scale reading.
- 6.2 Dielectric: Each instrument shall be tested by the methods of inspection listed in paragraphs 6.2.1 and 6.2.2.
- 6.2.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc. since this measurement is intended only to determine adequacy of insulation.
- 6.2.2 Overpotential Tests: Equipment shall not be damaged by the application of a test potential between electrical circuits and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with an R.M.S. value of five times the maximum circuit voltage or per paragraphs 6.2.2.1 or 6.2.2.2 whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds and then reduced at a uniform rate to zero.

Since these tests are intended to assure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

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- 6.2.2.1 Hermetically sealed instruments shall be tested at 200 volts R.M.S.
- 6.2.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.
- 6.3 Leak Test: The transmitter shall be tested for leaks immediately after the scale error test while the flow chamber is still moist from gasoline, but with all free gasoline drained out. The flow chamber shall be subjected to an air pressure of 40 psi and sealed off. During a five-minute period, there shall be no change in pressure indicated on a test gage capable of accurately distinguishing minimum changes of 0.125 psi.
- 6.4 Position Error: The difference in indicator reading when the indicator is rotated from the normal position to any other position shall not exceed  $2\frac{1}{2}\%$  of full scale reading.
7. QUALIFICATION TESTS: As many instruments as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations.
- 7.1 Low and High Temperature: The instrument shall be subjected to the applicable low and high temperatures as specified in para. 3.3.1, Column A for 3 hours. The scale errors determined for the indicator with gasoline also at the same temperature shall not exceed 6% of full scale value. Following this test and while still at the same temperature, the leak test of para. 6.3 shall be repeated.
- 7.2 Extreme Temperature Exposure: The instrument shall, after alternate exposures to the applicable low and high temperatures specified in para. 3.3.1, Column B for a period of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of para. 6.1. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.
- 7.3 Magnetic Effect: The magnetic effect of the indicator shall be determined in terms of the deflection of a free magnet, approximately  $1\frac{1}{2}$  inches long, in a magnetic field with a horizontal intensity of 0.18, plus or minus 0.01 gauss, when the indicator is held in various positions on an east-west line with its nearest part five inches from the center of the magnet.
- (An aircraft compass with the compensating magnets removed therefrom may be used as the free magnet for this test.) The maximum deflection of the magnet shall not exceed one degree for any pointer deflection.



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7.4 Humidity: The instrument shall be mounted in its normal operating position in a chamber maintained at a temperature of  $70 \pm 2^\circ\text{C}$  and a relative humidity of  $95 \pm 5\%$  for a period of six hours. After this period, the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than  $38^\circ\text{C}$ . This complete cycle shall be conducted:

- a. Five times for instruments located in uncontrolled temperature areas.
- b. Once for instruments located in controlled temperature areas.

Immediately after cycling, there shall be no evidence of damage or corrosion which affects performance following this test and the instrument shall be subjected to the scale error at room temperature test of 6.1. The change in reading between this test and the original scale error at room temperature test shall not exceed 2% of full scale reading.

7.5 Vibration:

7.5.1 Resonance: The instrument, while operating (fuel flowing through the transmitter), shall be subjected to a resonant frequency survey of the appropriate range specified in Section 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Section 3.3.3.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Section 3.3.3 at the resonant frequency for a period of one hour in each axis or with circular motion vibration whichever is applicable. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (Section 3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.5.2 Cycling: The instrument, while operating (fuel flowing through the transmitter), shall be tested with the frequency cycled between limits specified in Section 3.3.3 in 15-minute cycles for a period of one hour in each axis at an applied double amplitude specified in Section 3.3.3, or an acceleration specified in 3.3.3 whichever is the limiting value or a total of three hours for circular motion vibration, whichever is applicable.

After the completion of this vibration test, no damage shall be evident and the instrument shall meet the applicable requirements of Section 6.

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- 7.6 Blocked Movable Element: The pressure drop with the transmitter movable element blocked in the zero flow position, measured by any suitable method, shall not exceed the values tabulated below:

<u>RATE OF FLOW (PPH)</u>	<u>PRESSURE DROP (PSI)</u> (Ref. 4.6)
1000	2.75
1500	3.00
2000	3.25
3000	3.50

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